Structure Functions and Parton Densities Working Group

Theoretical Summary

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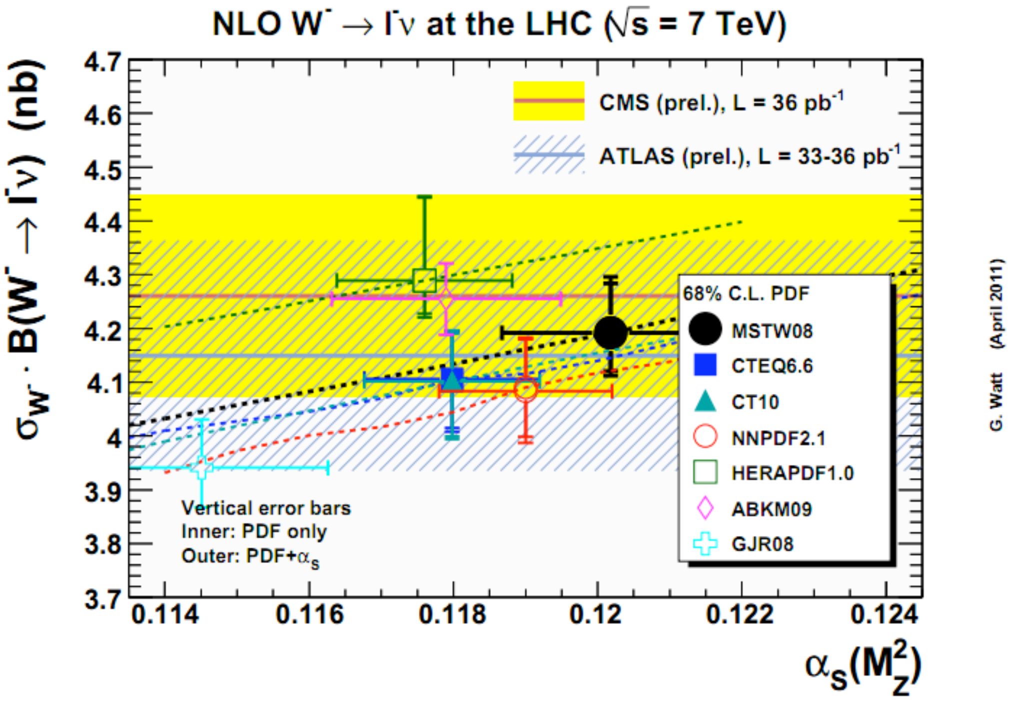
Maria Ubiali (RWTH Aachen)

- Progress and ongoing studies from PDFs fitting collaborations
- Nuclear versus free nucleon partons
- New constraints on PDFs

PDFs

- How do we interpret the differences between PDFs predictions?
- Shall we just pick a set out of the PDFs "supermarket" shelf?



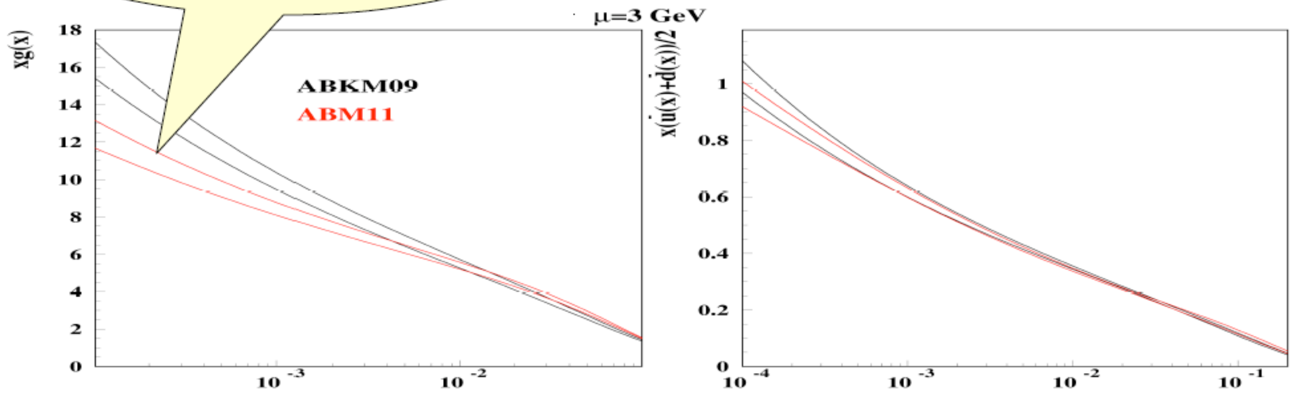
Huge effort in understanding differences & improving theoretical and statistical treatment in analyses

Updates in PDFs determination

S. Alekhin

ABM11 = ABKM09
+ HERA inclusive combined data
+ H1 low-energy data
+ 3-loop correction to F_L
+ running-mass definition

Impact of new inclusive HERA data: normalization and shape



	$\alpha_s(M_Z)$
ABKM09	0.1135(14)
ABM11	0.1134(11)

The value of χ^2/NDP=3318/2968=1.1

The PDF shape was modified to accommodate new data

$$xS(x) = exp\left[a \ln x(1 + \beta \ln x)(1 + \gamma_1 x)\right](1 - x)^b$$

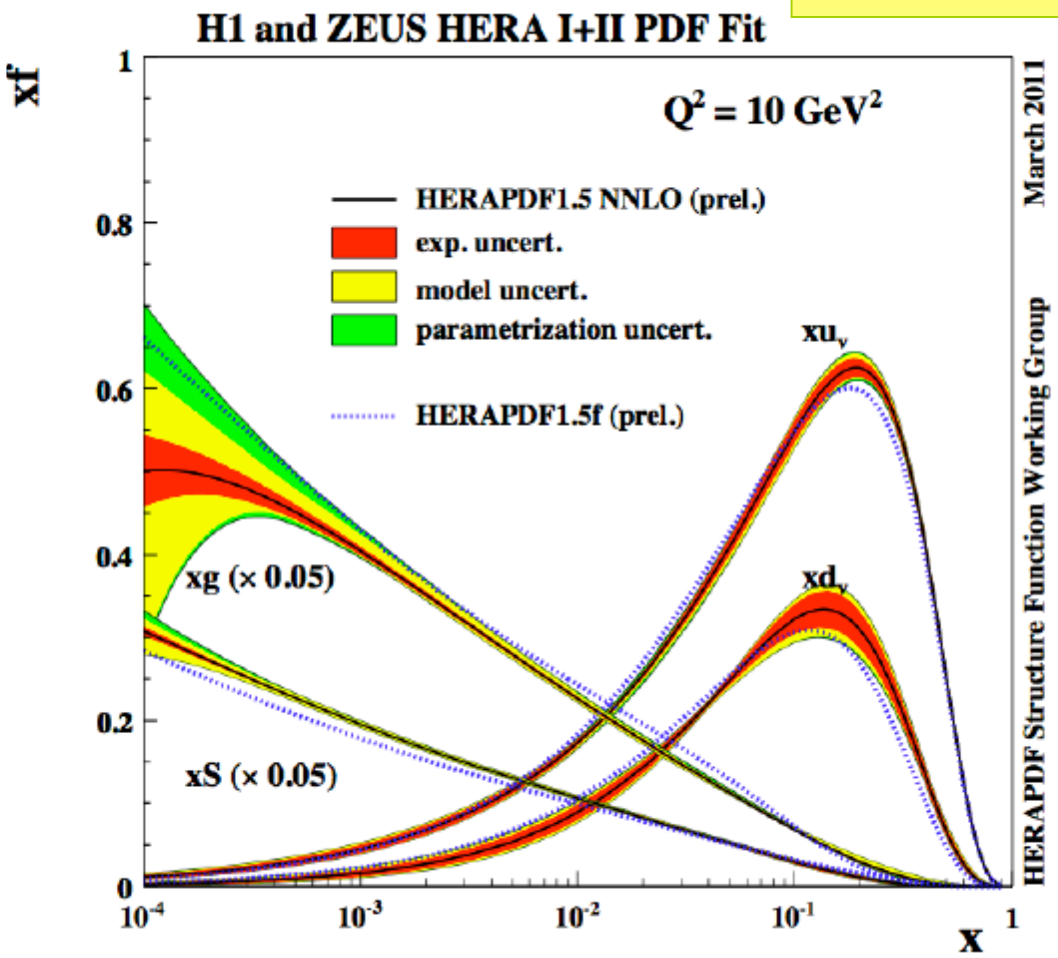
$$xu_V(x) = exp\left[a \ln x(1 + \gamma_1 x + \gamma_2 x^2 + \gamma_3 x^3)\right](1 - x)^b$$

Updates in PDFs determination

A. Caldwell

HERAPDF1.5

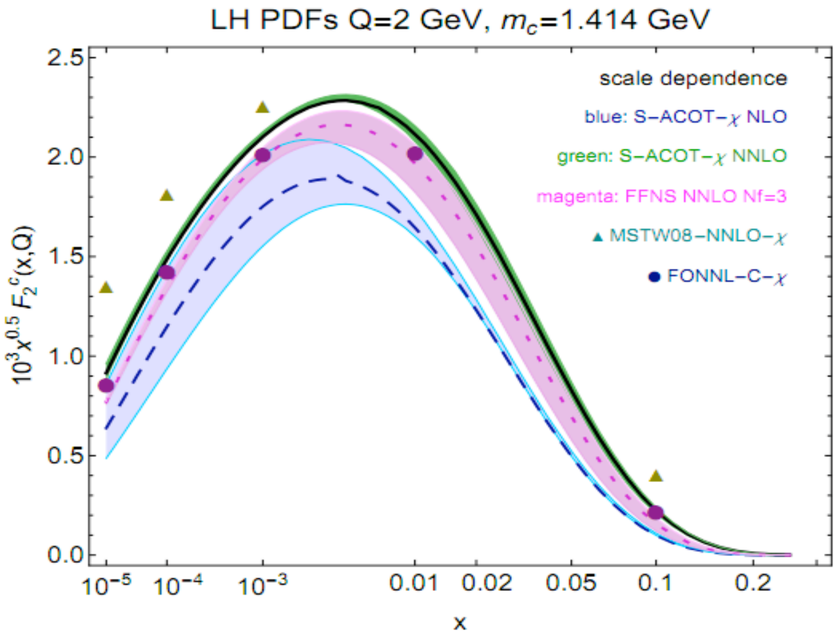
- HERAI + II, NC+CC
- More flexibility required by NNLO (10 → 14 parameters gluon and $u_v \neq d_v$ at small-x)
- HERAPDF1.5f is NLO fit with same parametrization



Updates in PDFs determination

- Accuracy of many EW, DIS, jets data becomes comparable to NNLO contribution.
- Towards NNLO parton fits from the global fits: CT and NNPDF

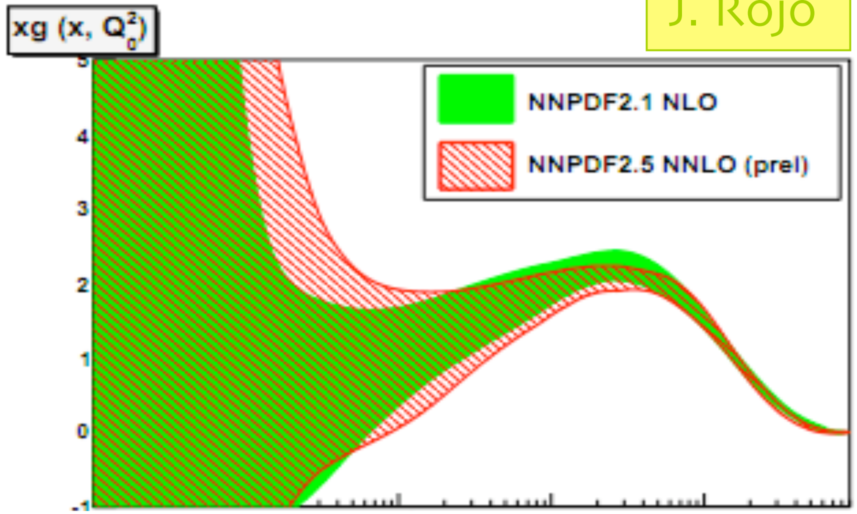
P. Nadolsky, M. Guzzi

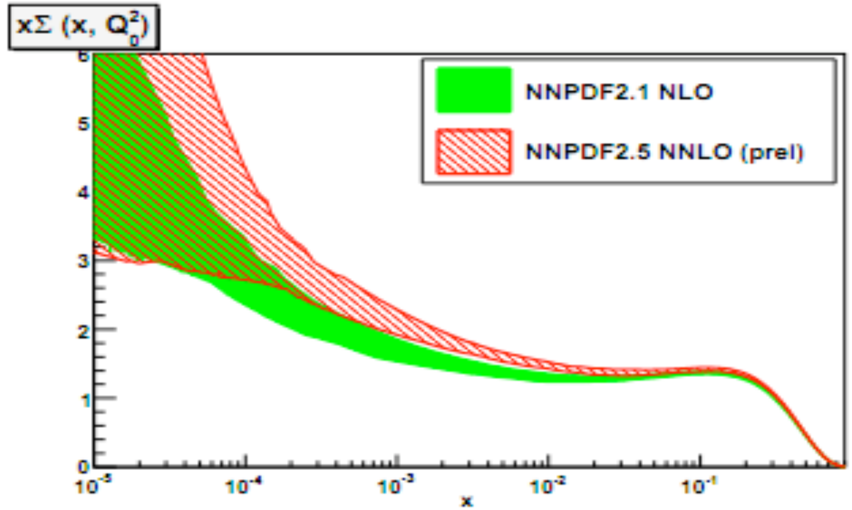


S-ACOT NNLO and FONLL-C lead to very similar results

CT10 @ NNLO and NNPDF2.5 (NNLO) will be available soon

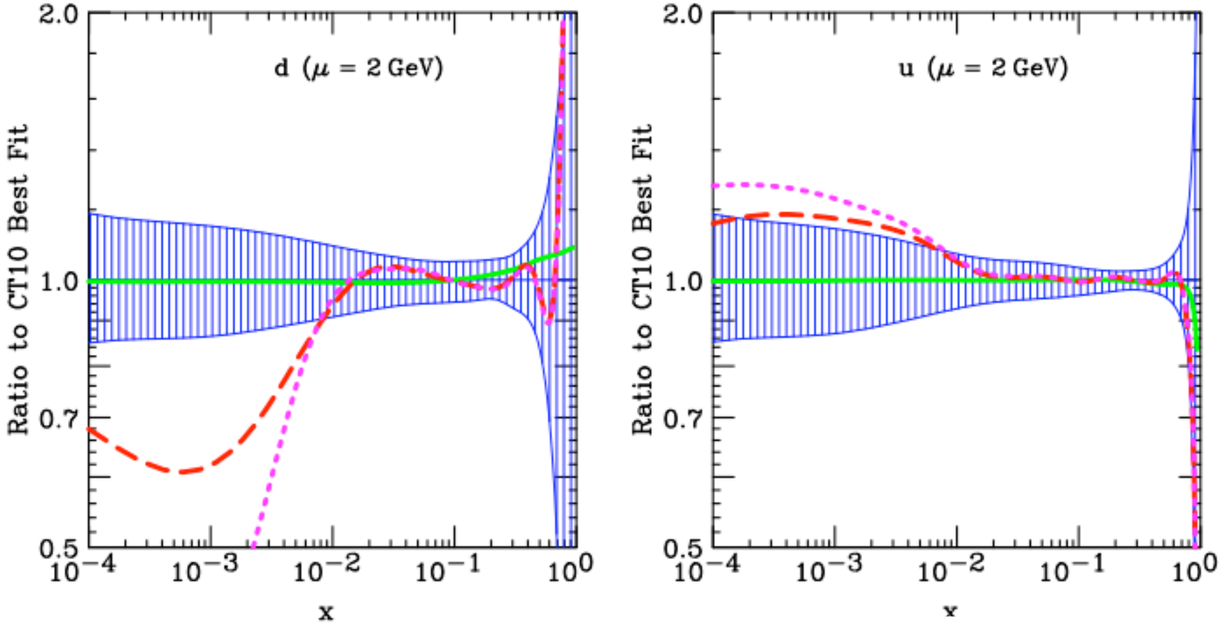
J. Rojo





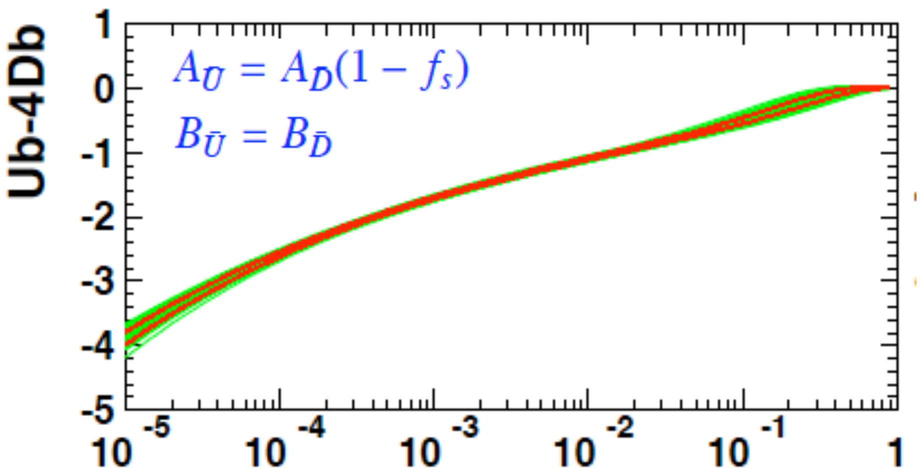
Parametrization

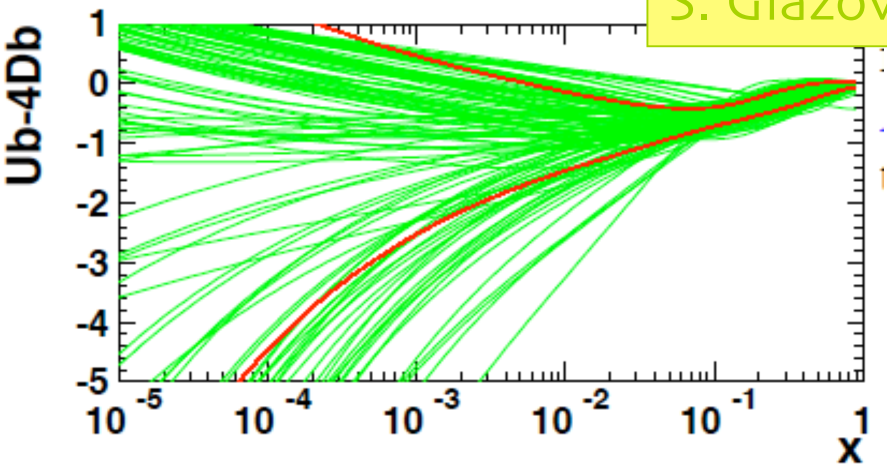
J. Pumplin



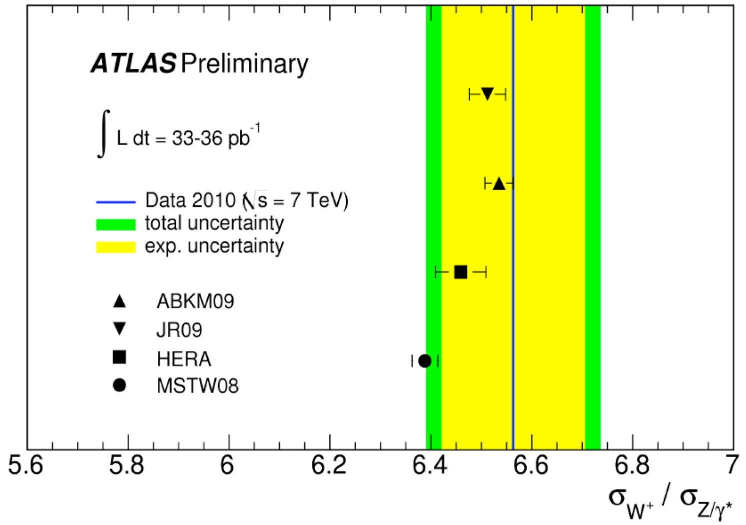
- Study on parametrization flexibility: Chebyshev polynomial (~80 pars) + smoothing criterion lead to equivalently good fits
- Study on flavor assumptions: light flavor and valence-sea quarks separation

S. Glazov



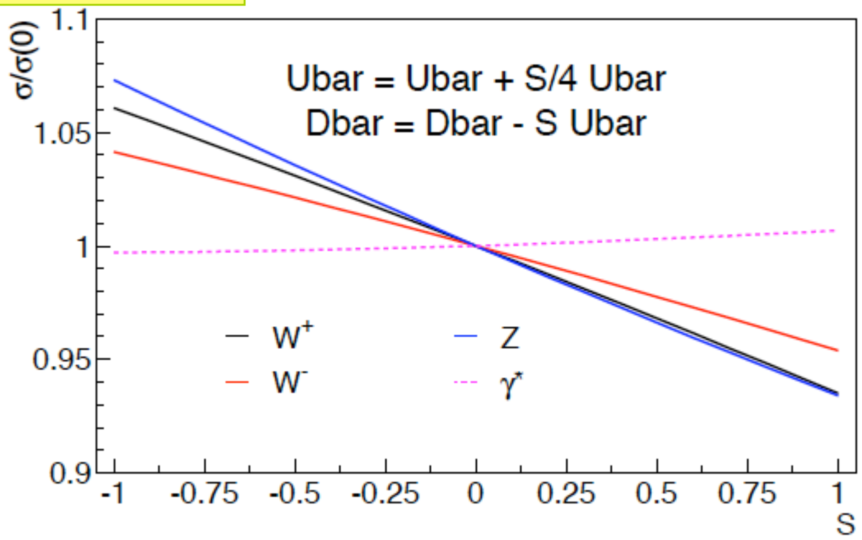


PDFs for & at the LHC



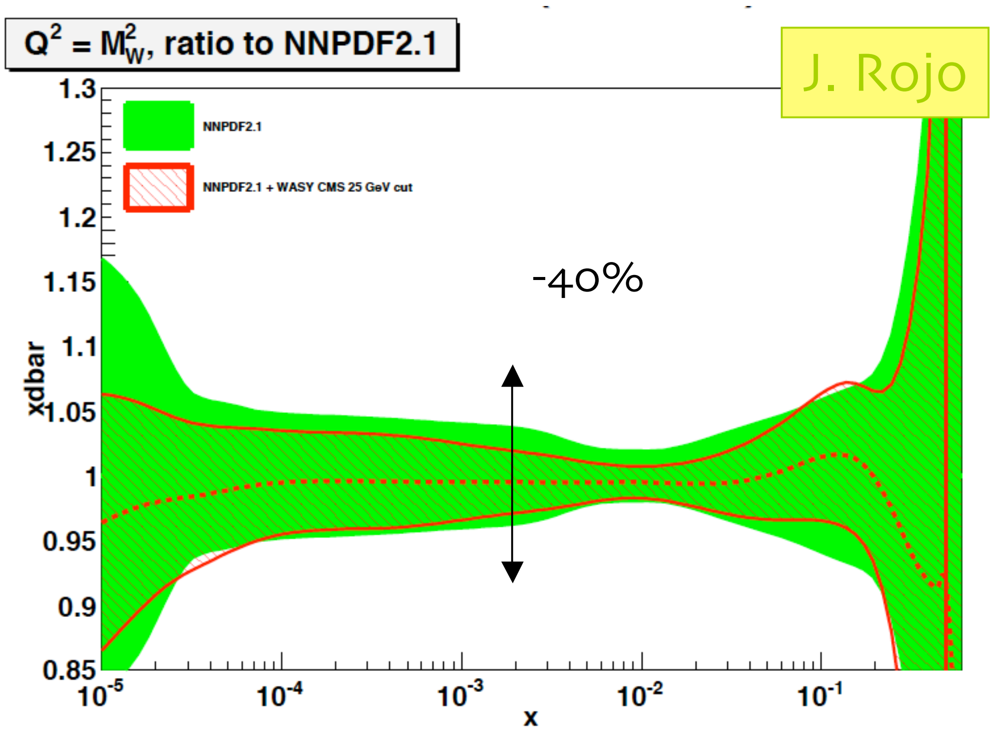
- ✓ Predictions for LHC get closer as theoretical and statistical treatment are refined
- ✓ LHC has a potential for discriminating among different PDFs model
- ✓ LHC data provide constraints to PDFs

S. Glazov



Total production cross sections

J. Rojo

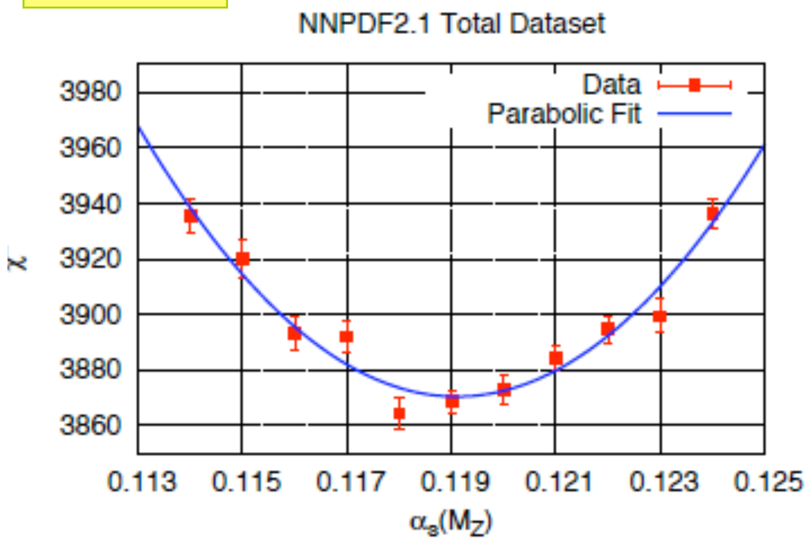


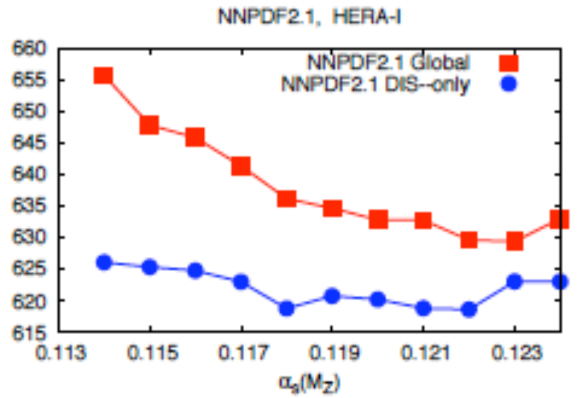
LHC CMS and ATLAS W lepton asymmetry

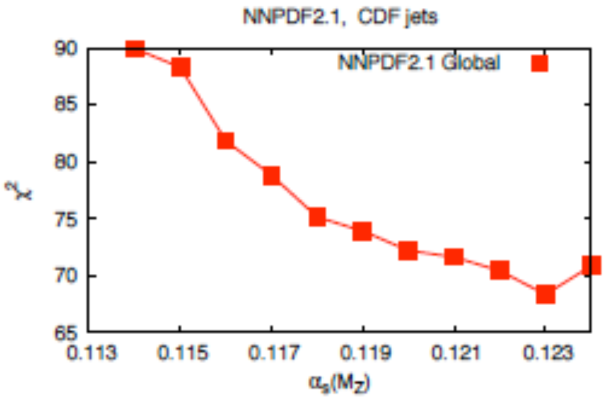
The α_s puzzle

J. Rojo

NNPDF2.1: α_s varied as external parameter and χ^2 curve fitted to determine it from global fit. Determination driven by jets data: $0.1191(6)^{stat}$



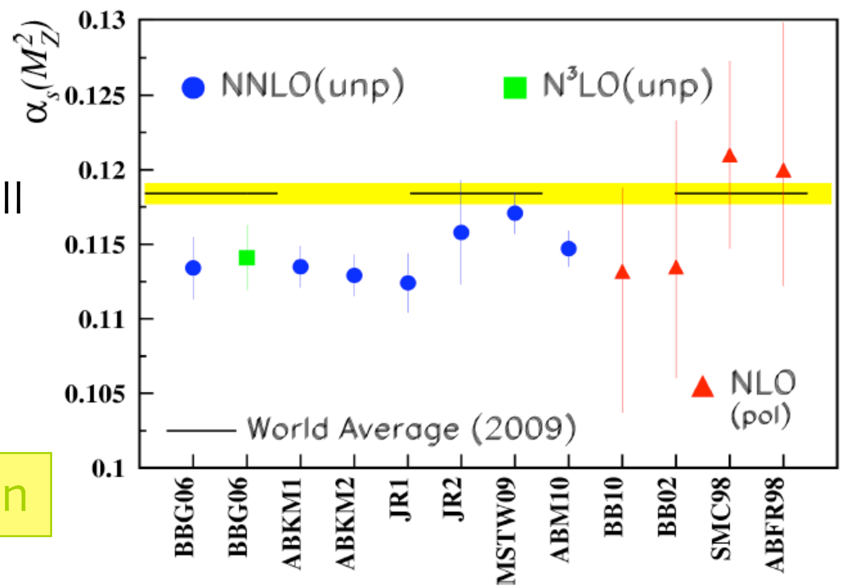




ABM: α_s fitted as a parameter of the fit. NNLO fit for α_s far from world average. Jets data push 1σ up but still below world average.

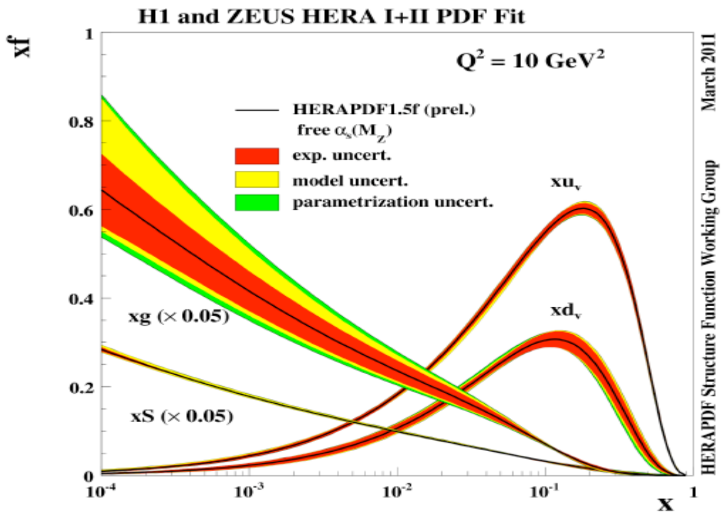
ABKM:	0.1135(14)
+ D0(1jet):	0.1149
+ D0(2jet):	0.1144
+ CDF/k_T	0.1141
+ CDF/cone(prel.)	0.1130

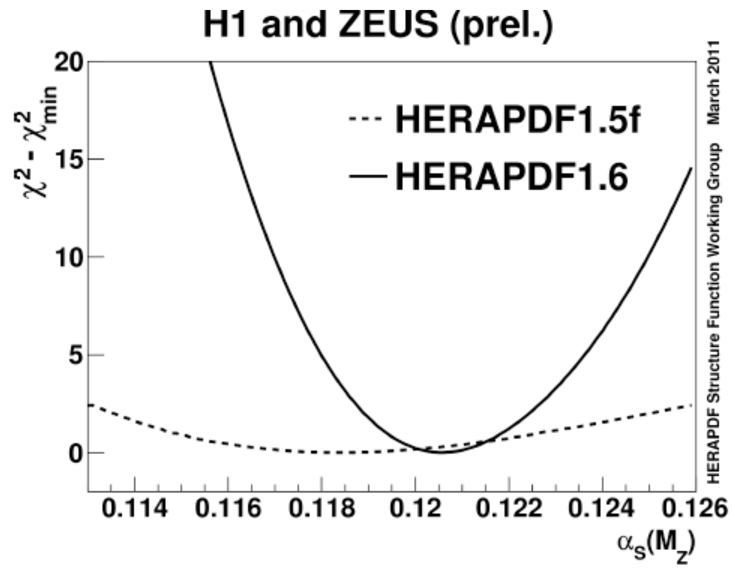
S. Alekhin



The α_S puzzle

No jets, α_s free





HERAPDF1.6

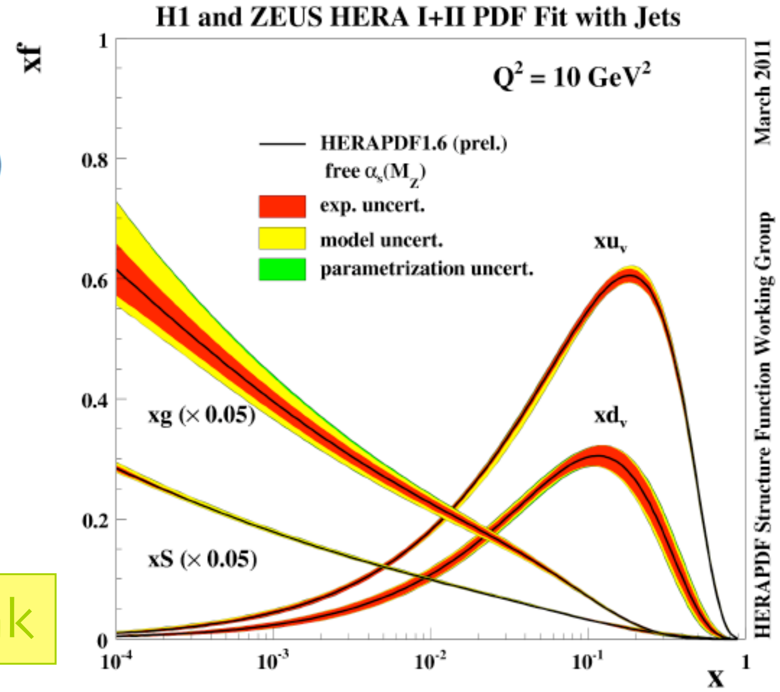
Add HERA JETS data. DIS data insensitive to α_S,
Once JETS data are fitted χ^2sensitive to α_S variation.

0.1202

$\pm 0.0013\,(exp)$
$\pm 0.0007\,(mod/\,par)$
$\pm 0.0012\,(hadr)$
$^{+0.0045}_{-0.0036}\,(scale)$

K. Nowak

With jets, α_s free

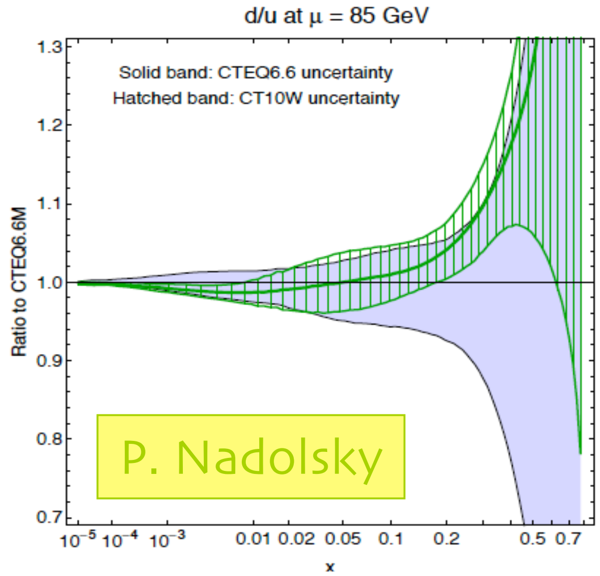


Spread of α_S determinations from parton fits larger than nominal uncertainty for each. Different data? Theory?

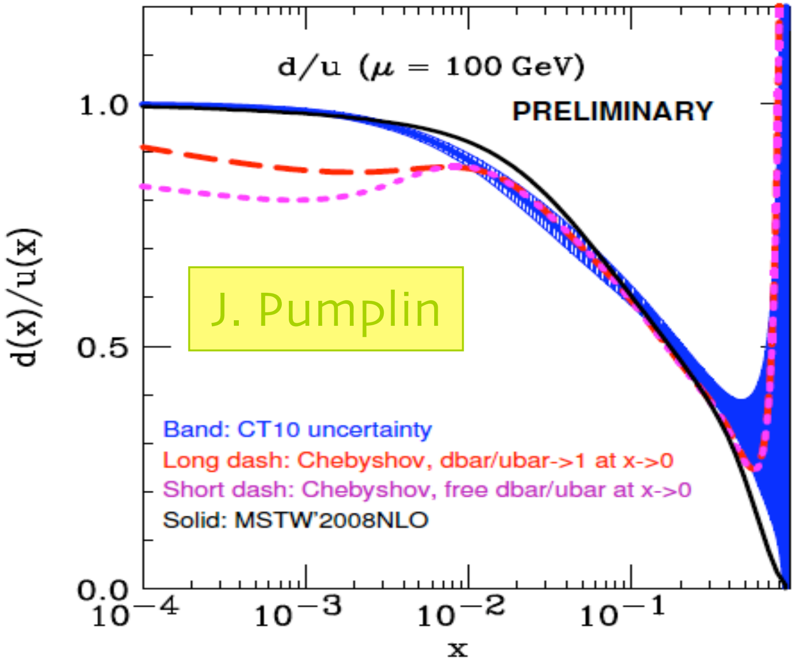
The Tevatron W lepton asymmetry puzzle

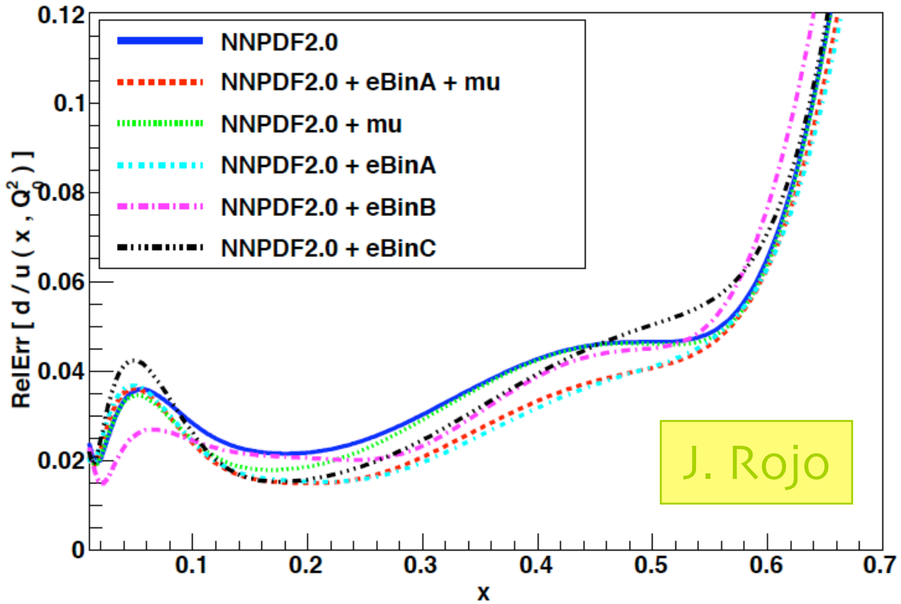
$$
\begin{aligned}
A(y_W) &= \frac{\frac{d\sigma(W^+)}{dy_W} - \frac{d\sigma(W^-)}{dy_W}}{\frac{d\sigma(W^+)}{dy_W} + \frac{d\sigma(W^-)}{dy_W}} \\
&\simeq \frac{u(x_1)/d(x_1) - u(x_2)/d(x_2)}{u(x_1)/d(x_1) + u(x_2)/d(x_2)}
\end{aligned}
$$

Apparent tension between D0 Tevatron asymmetry data and DIS deuteron data (also for inclusive p_T bin). Why?



a) Not enough flexibility in d/u shape?



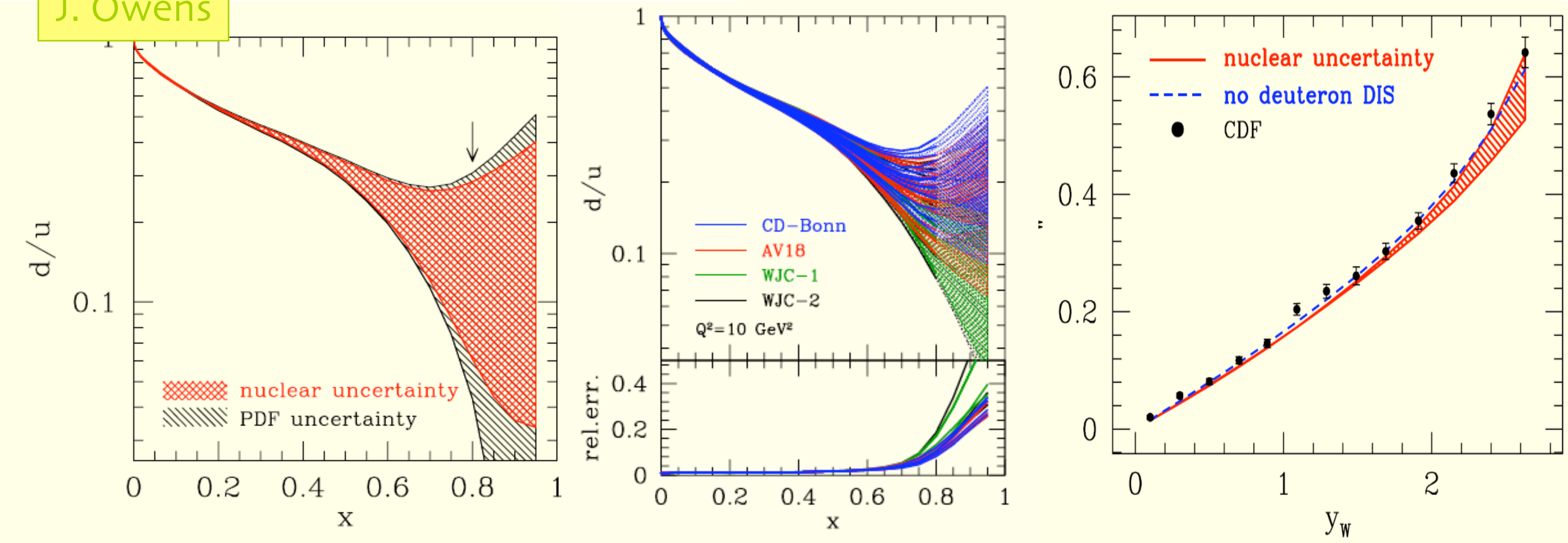


The Tevatron W lepton asymmetry puzzle

b) Nuclear corrections to deuteron data?

$Q^2 > 1.69\ \mathrm{GeV}^2,\ W^2 > 3\ \mathrm{GeV}^2$

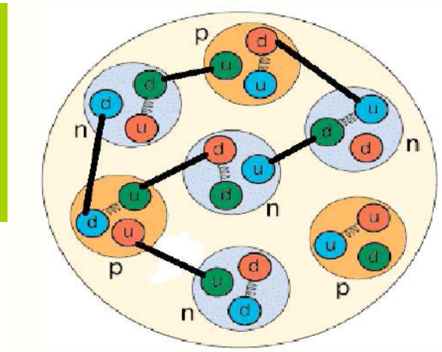
J. Owens



NUCLEAR UNCERTAINTY:
Weak Binding Approx(Fermi motion)
+ Offshellness corrections

Fit without deuteron exhibits larger uncertainty at large x wrt when one nuclear model is fitted BUT it fits better W asymmetry data

Nuclear corrections



DIS off a bound nucleon different from DIS off a free nucleon.
EMC effect: valence quarks in nuclei carry less momentum than valence quarks in nucleons

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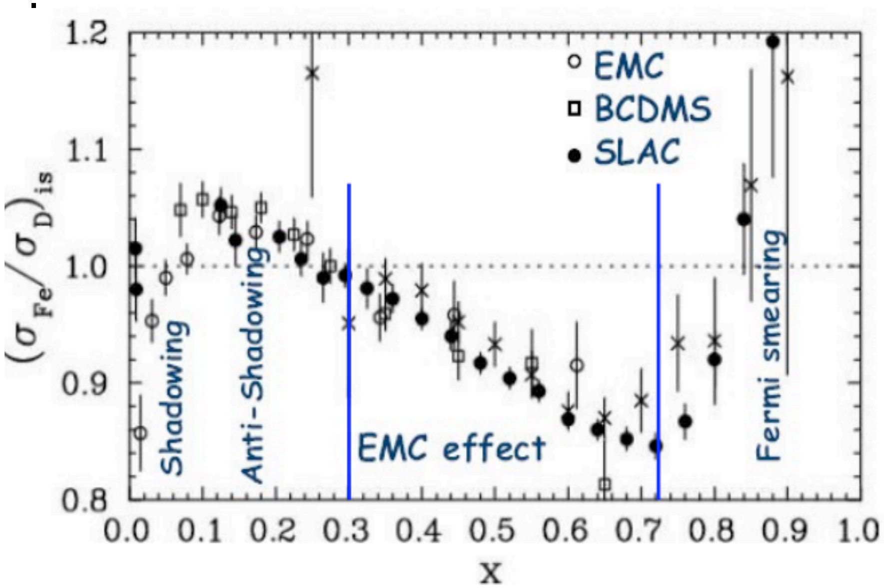
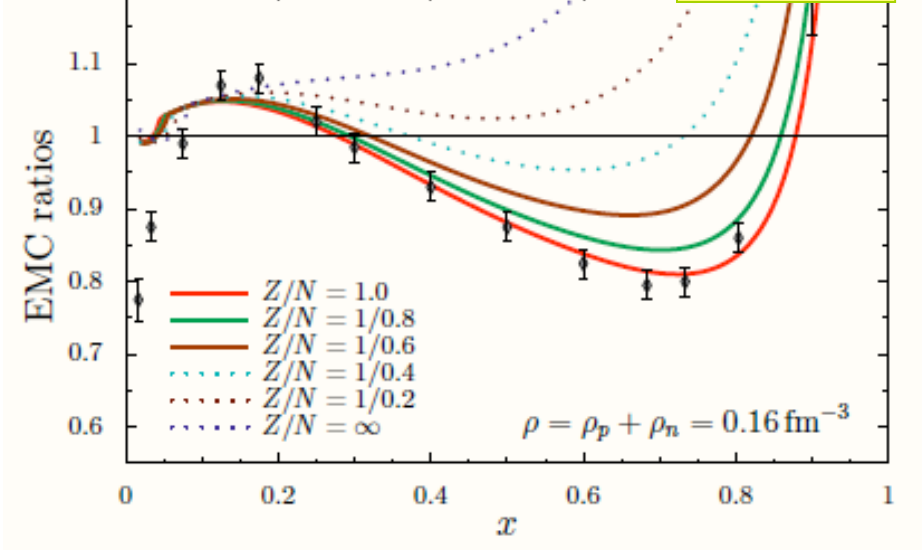


I. Cloet



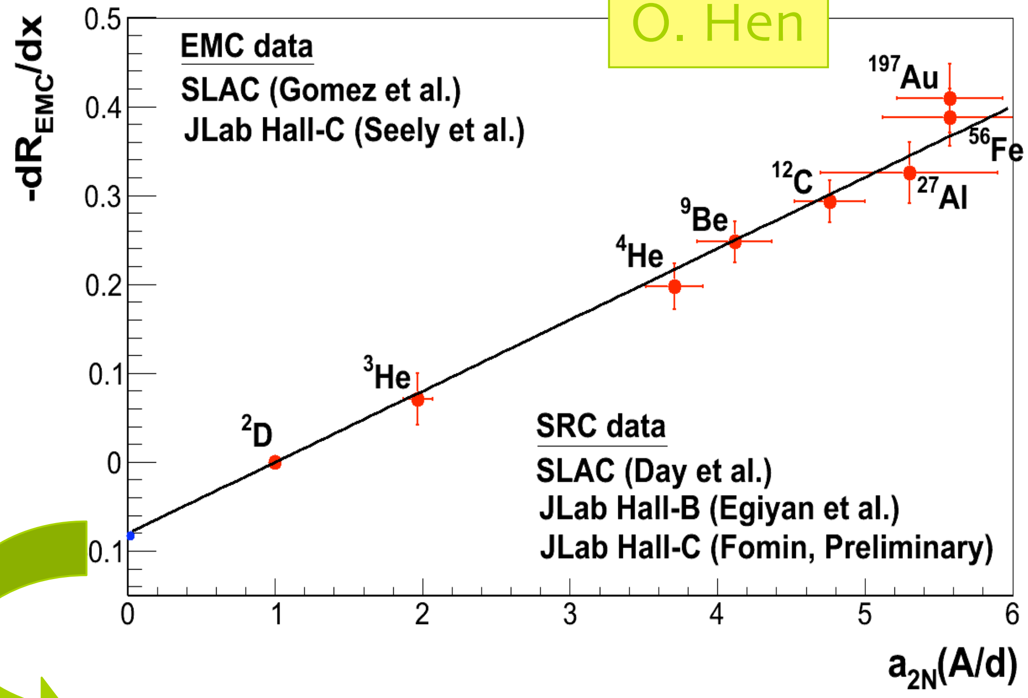
EMC effect interpreted as medium modification of the bound nucleon wave function (mean field couples to quarks in the nucleons)

$$R = \frac{F_{2A}}{F_{2A,\mathrm{naive}}} = \frac{F_{2A}}{Z\,F_{2p} + N\,F_{2n}} \simeq \frac{4\,u_A(x) + d_A(x)}{4\,u_f(x) + d_f(x)}$$

Can explain NuTeV anomaly and bring to full agreement with SM

Nuclear corrections

O. Hen

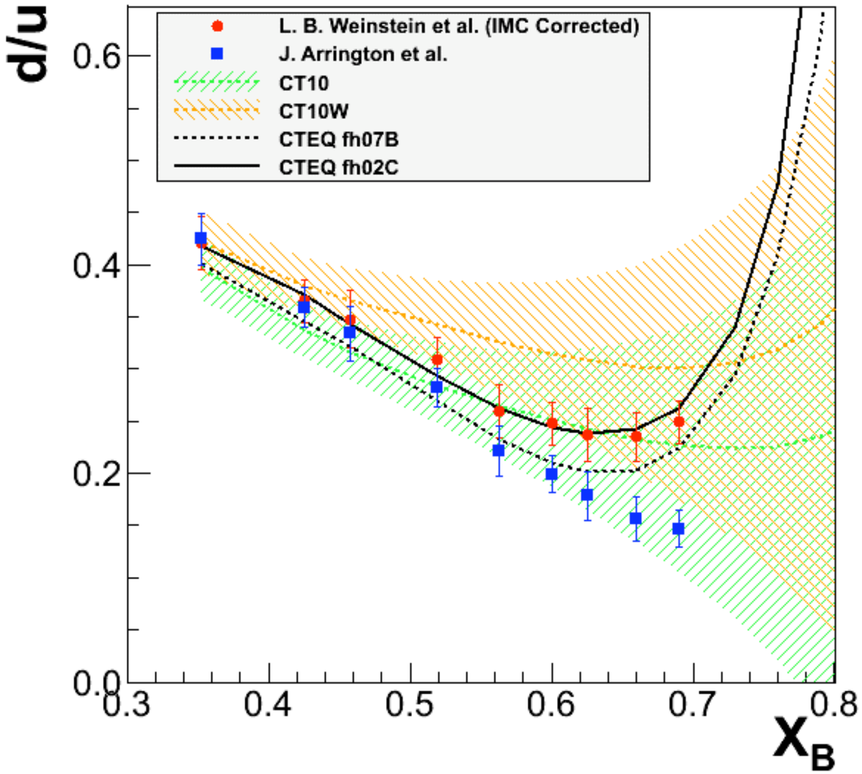


Other phenomenological perspective: the EMC effect is NOT due to average medium effect but to local density effect (number of 2N-ShortRangeCorrelation)

E. Piasetzky

Extrapolate to free proton plus nucleon and apply correction factor to the SLAC F2n/F2p data

$$\frac{F_2^n(x_B,Q^2)}{F_2^p(x_B,Q^2)} = \frac{2F_2^d(x_B,Q^2)/F_2^p(x_B,Q^2) - [1 - a(x_B - b)]}{[1 - a(x_B - b)]}$$



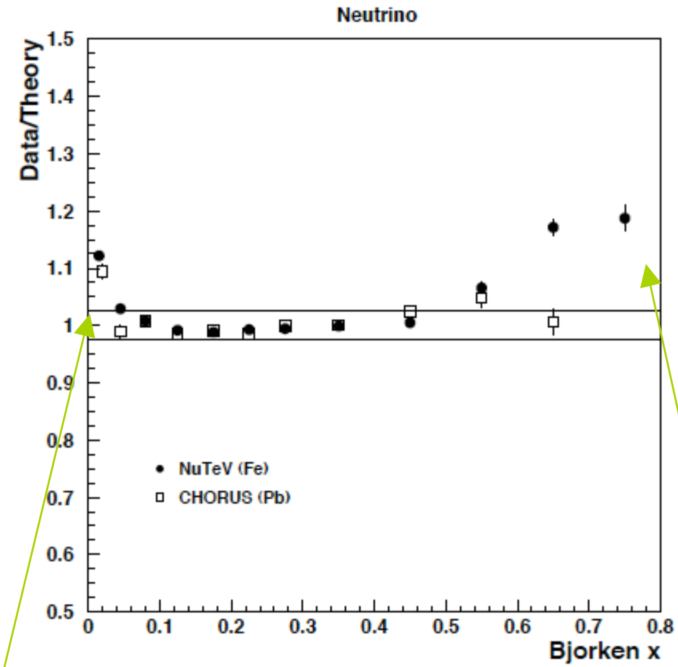
[See also P. Solvignon talk on Coulomb effect]

Nuclear corrections

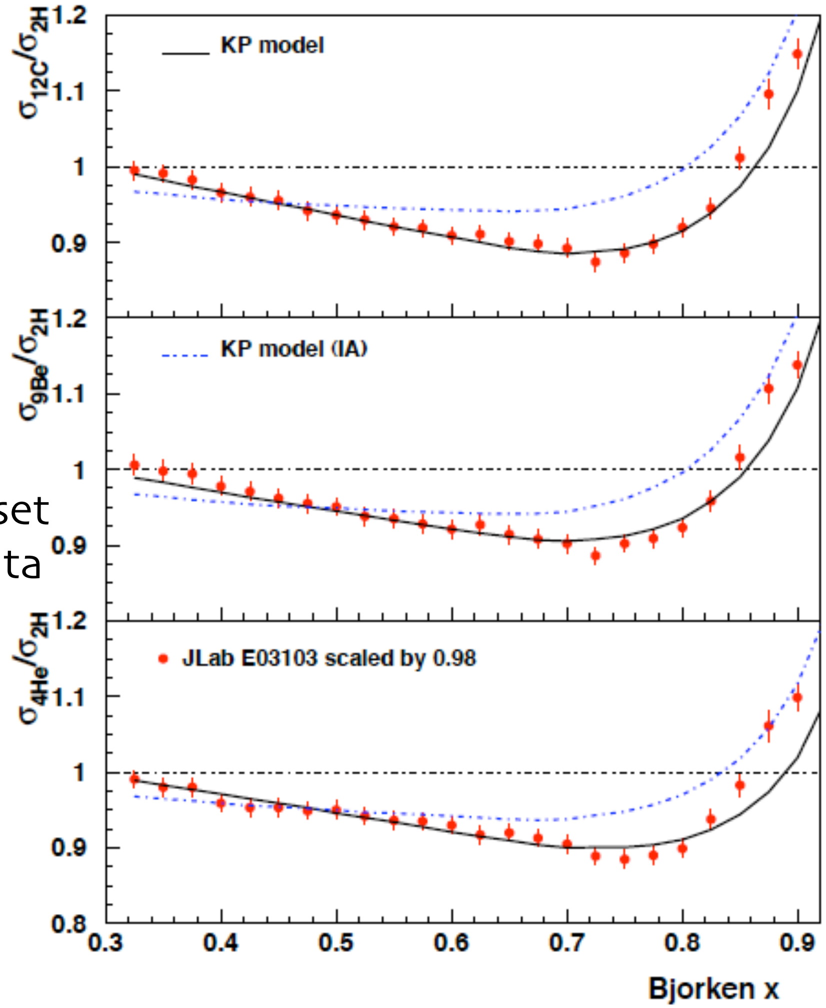
S. Kulagin

New model which takes into account major nuclear effects

- Nuclear spectral functions with mean field & correlation
- (Anti)Shadowing corrections
- Fermi motion
- Off-shell correction
- Isoscalar and isovector contributions



From good agreement with NMC, SLAC and HERMES extract normalization offset in JLAB E03103 data



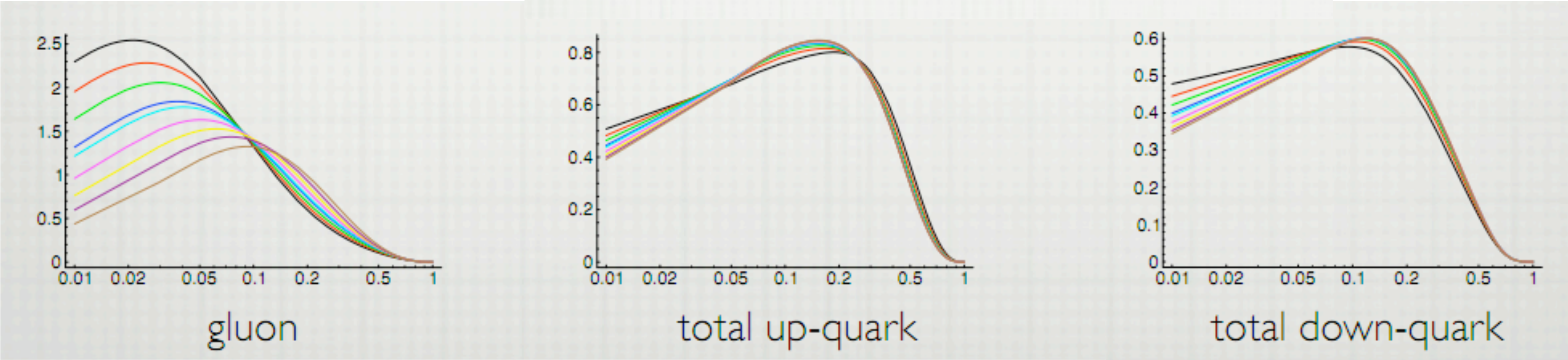
Data/Theory comparison for nuclear differential cross sections from NuTeV and CHORUS

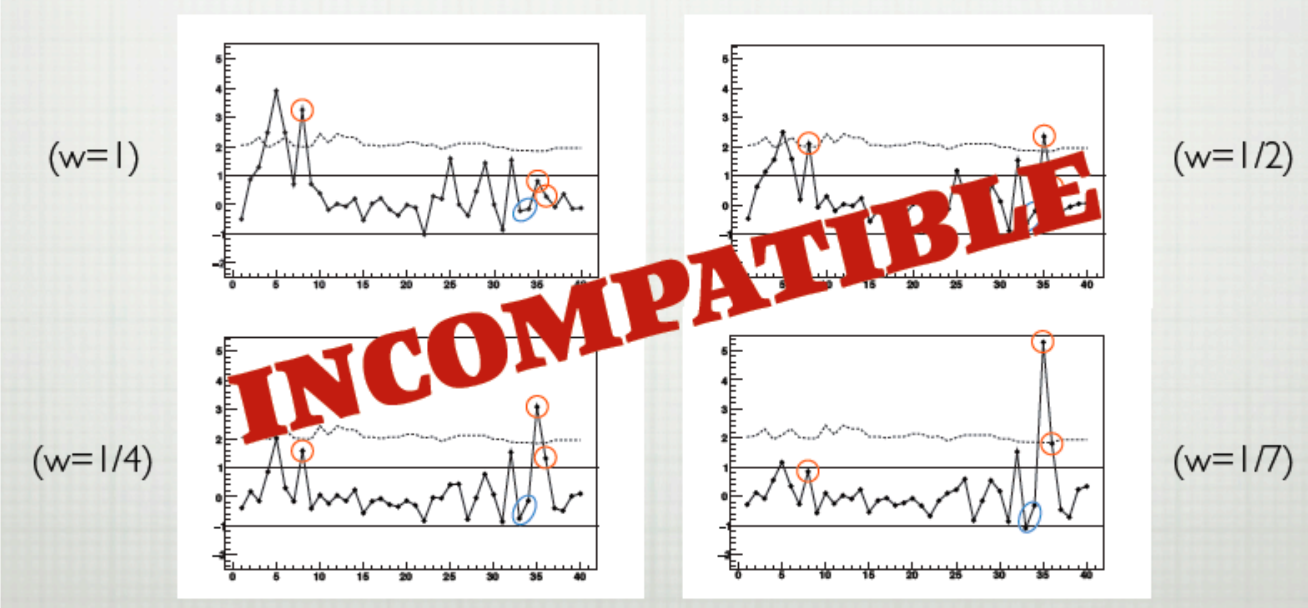
Nuclear PDFs

nPDFs $\cancel{f_i^A = R_i^{A,Z} f_i}$ $\cancel{f_i^A = W_i^{A,Z} \otimes f_i}$

K. Kovarik

CTEQ6M parametrization + $c_k \to c_k(A) \equiv c_{k,0} + c_{k,1}\left(1 - A^{-c_{k,2}}\right), \quad k = \{1, \ldots, 5\}$





Nuclear PDFs analysis suggest incompatibility between neutrino DIS and charged lepton DIS.

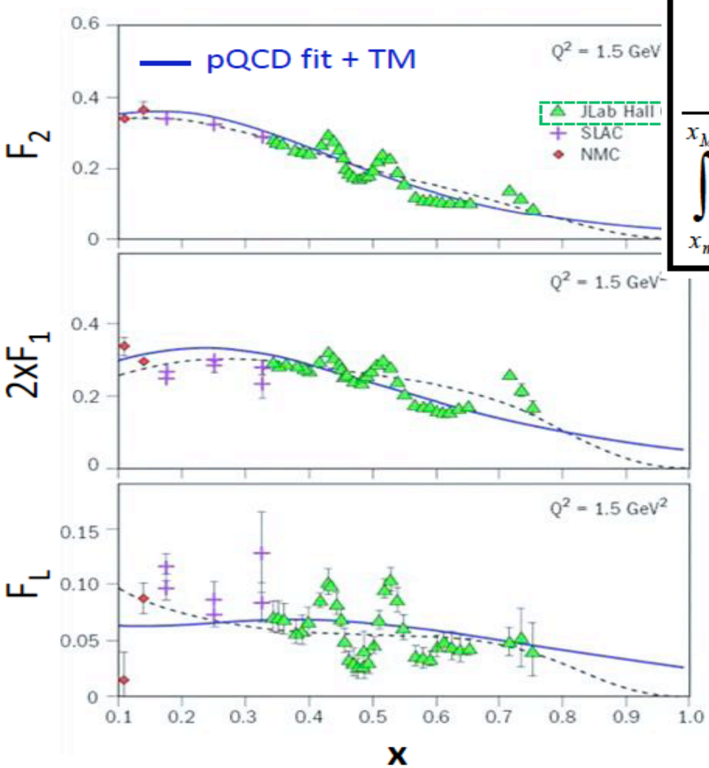
High-x / Low-Q^2 region exploration

When you go to high-x/low-Q^2 issues

- Target Mass Corrections
- Higher twists [Alekhin,CTEQ-JLAB]
- Nuclear Effects [Kulagin,Hen,Owens…]
- Resonances [Malace]

[Note also talk from A. Bodek on effective LO PDFs model]

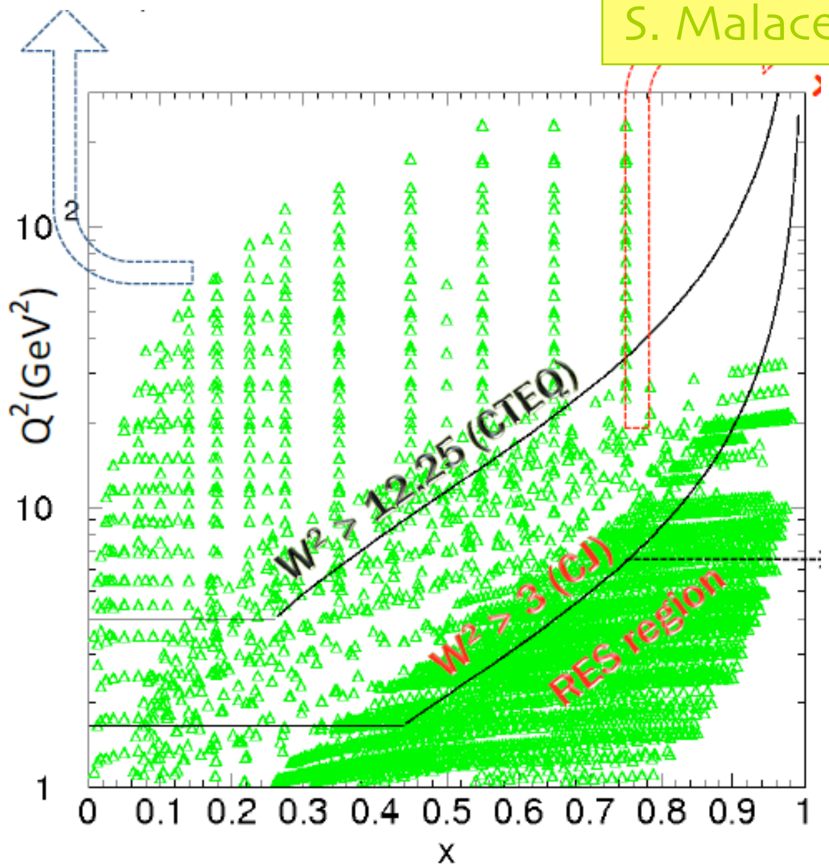
Averaged resonance data help in constraining very large x region. But need to make sure of quark-hadron duality



$$\frac{\int_{x_m}^{x_M} F_2^{data}(x,Q^2)dx}{\int_{x_m}^{x_M} F_2^{QCD\ calc.}(x,Q^2)dx}$$

Resonances average to QCD curves if ration tends to one.

S. Malace



Summary

- Great effort has been made to converge on theoretical (Heavy flavor, NNLO) and statistical treatment (parametrization, compatibility) for determining PDFs

- Data from fixed nuclear targets are corrected by nuclear factors. Many ideas and hints for modeling and understanding it

- More precision on PDFs can be achieved from many sources: LHC, JLAB or neutrino experiments but phenomenological - theoretical work is needed

Summary

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THANKS TO THE ORGANIZERS
AND
TO ALL THE SPEAKERS !!!

APOLOGIES TO THOSE WHOM I DID NOT HAVE TIME TO MENTION